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MEASUREMENT OF PERFORMANCE OF HOLLOW SHAFT VENTILATORS ON D.E.R.D. SHEARERS AT LINGAN MINE

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MEASUREMENT OF PERFORMANCE OF HOLLOW SHAFT
VENTILATORS ON D.E.R.D. SHEARERS AT LINGAN MINE

by

W.G. Klinowski* and G.A. Haslett**

ABSTRACT

The effective ventilation of the zones around the face clearance ring (face plate) and the vane picks of a shearer drum has always been problematic as the lead drum on a shearer cuts into and loads from a coal buttock.

The obscuration of the drum by the buttock has an inherent danger inasmuch as it inhibits the ventilation of the cutting zone and increases the likelihood of flammable methane-air mixtures at the drum location.

A potential solution to this problem was the introduction during the 70's of hollow shaft ventilators onto shearer drums. Such ventilators have now been in use for more than ten years in a number of countries. No authoritative information has yet been published on their performance.

This paper describes the results of some tests undertaken on shearers at CBDC's Lingan Mine. The results of these tests are rather more qualitative than quantitative because of problems causally due to lack of control on variables which generally occur when conducting tests on full-scale operating plant. They nevertheless provide some useful information on the performance of hollow shaft ventilators at CBDC's Lingan Mine.

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MESURE DU RENDEMENT DES VENTILATEURS À ARBRE TUBULAIRE SUR LES
HAVEUSES À DOUBLE TAMBOUR DE LA MINE LINGAN

par

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RÉSUMÉ

La ventilation de façon efficace des zones entourant la plaque de devant du tambour et des pics du tambour de coupe a toujours soulevé un problème puisque le tambour de tête d'une haveuse abat et déblaie le charbon à même le parement.

L'obstruction du tambour par le parement représente un danger inhérent vu que ce genre d'obstruction empêche la ventilation de la zone de coupe et augmente les possibilités de la formation d'un mélange méthane-air inflammable au niveau du tambour.

Une solution potentielle à ce problème a été l'installation de ventilateurs à arbre tubulaire sur les tambours de coupe au cours des années 70. Bien que cela fait plus de dix ans que ces ventilateurs soient utilisés dans plusieurs pays, aucune information faisant autorité sur le rendement de ces ventilateurs n'a été publiée jusqu'à maintenant.

Ce rapport présente une description des résultats obtenus au cours de certains essais effectués sur les haveuses à la mine Lingan de la SDCB. Les résultats de ces essais ont tendance à être beaucoup plus qualitatifs que quantitatifs, en raison des problèmes qu'occasionne le manque de contrôle sur les variables qui se présentent généralement lorsqu'on effectue des essais en usine dans des conditions d'exploitation. Ces résultats fournissent néanmoins des renseignements utiles sur le rendement des ventilateurs à arbre tubulaire à la mine Lingan de la SDCB.

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INTRODUCTION

Hollow shaft ventilators have previously been tested in some of the mines operated by the Cape Breton Development Corporation. The volumes of air delivered to the cutting zones of some shearers via their hollow shafts has been measured and reported (1). However, these previous tests did not evaluate any effect that the hollow shaft ventilators were producing on the methane-air mixtures within the zones of operation of the cutting picks.

Several tests using the tracer gas techniques were performed. The results, although discrete in nature, provided some information on the methane-air mixtures in the cutting zones and some further indications about efficiencies and the performance levels of the hollow shaft ventilators during the progress of cutting coal.

HOLLOW SHAFT VENTILATOR

The hollow shaft ventilator is a device which induces an airflow from the free conveyor track through the bore of the hollow drum shaft on a shearer to the area around the drum face plate. Its purpose is to ventilate the zone around the multiple cutting picks upon the drum face and replace any methane that is released to non-flammable concentrations with air. The hollow bore of the drum shaft is equipped with a high pressure water spray. The water spray induces an axial airflow along the hollow shaft to discharge around the drum face plate.

It is recognized that three factors (1) have a major impact upon the efficiency of the hollow shaft ventilator:

1) Design

The diameter of the hollow shaft, its geometry and specification of the water spray nozzle (location, area, spray pattern) will, in combination, dictate the maximum level of performance that can be attained.

2) Discharge Water Pressure

The water spray nozzle discharge entrains air and causes it to flow into the hollow shaft. The volume of air induced to flow through the system is directly related to the nozzle discharge pressure.

3) Mechanical Blockages and Damage

Accumulations of coal and dirt at the intake of the hollow shaft will reduce or stop the flow of air through the system. On shearers equipped with ranging outboard arms total blockage of the intake is not uncommon. Blocked or damaged water supply pipes and nozzles are also a common fault.

TEST EQUIPMENT

MEASUREMENT OF THE AIRFLOW INDUCED BY H.S.V.

An orifice plate flow measuring device complete with an adapter to match an existing flat surface on the shearer's shaft surrounding the H.S.V. inlet was used. Pressure drops across the orifice were measured during the test and compared with the wind tunnel calibration curves to obtain the airflow through the hollow shaft.

TRACER GAS RELEASE SYSTEM

Tracer gas (SF_6) was released from the small lecture bottle through a pressure regulator and a flow restrictor. The system delivered a steady flow of tracer gas and the rate of flow was measured using a soap flowmeter.

SAMPLES COLLECTION AND STORAGE

Methane-air samples from the cutting zones were withdrawn using tygon tubing within a long probe and collected in either Mylar air bags or plastic disposable syringes. Following the testing, the samples were analysed on the gas chromatograph for the tracer gas and methane content.

TEST PROCEDURES

To obtain results which would closely approximate to the real operating conditions, a series of methane-air samples from behind the revolving drums would need to be withdrawn. Since this is practically impossible on an operating face the testing procedures had to sacrifice in some part the sample accuracy, but the errors incurred due to a time lapse between cutting and sampling (probably within a range of 30%) still allowed for the valid interpretation of the results and for the practical assessment of the H.S.V.'s performance.

A sampling zone was chosen in the wall and the tracer gas release system was attached to a shield on the face. The H.S.V. induced airflows were measured for each test on both drums before the tracer gas was introduced.

When the shearer in cut approached the sampling zone, tracer gas of a known quantity was delivered via tygon tubing into the H.S.V. inlet on the leading drum. After a few further meters of cutting, when the leading drum arrived into the sampling location, the shearer was stopped, its direction reversed and a gap of about 20 - 30 cm was created between the circular cutting profile and the revolving drum. In that time methane-air samples were rapidly withdrawn from the point where the end of the probe touched the new face; usually four to six samples along the drum perimeter. After the collection of the leading drum samples, the shearer then progressed in cut further along the wall and an additional two to four samples were taken from behind the machine's body. The tracer gas supply tubing was then inserted into the H.S.V. within the trailing drum and after a few extra meters of cutting, four to six samples were taken along the accessible perimeter of the trailing drum - this time without stopping the shearer. The general pattern of sampling is presented in Figure 1. Identified samples were analysed for SF_6 and methane concentrations shortly after testing and delivery to the Cape Breton Coal Research Laboratory.

The test method described was carried out on the shearers operating in 6 West and 10 East walls at Lingan Mine, in each wall testing was done in both directions of cutting.

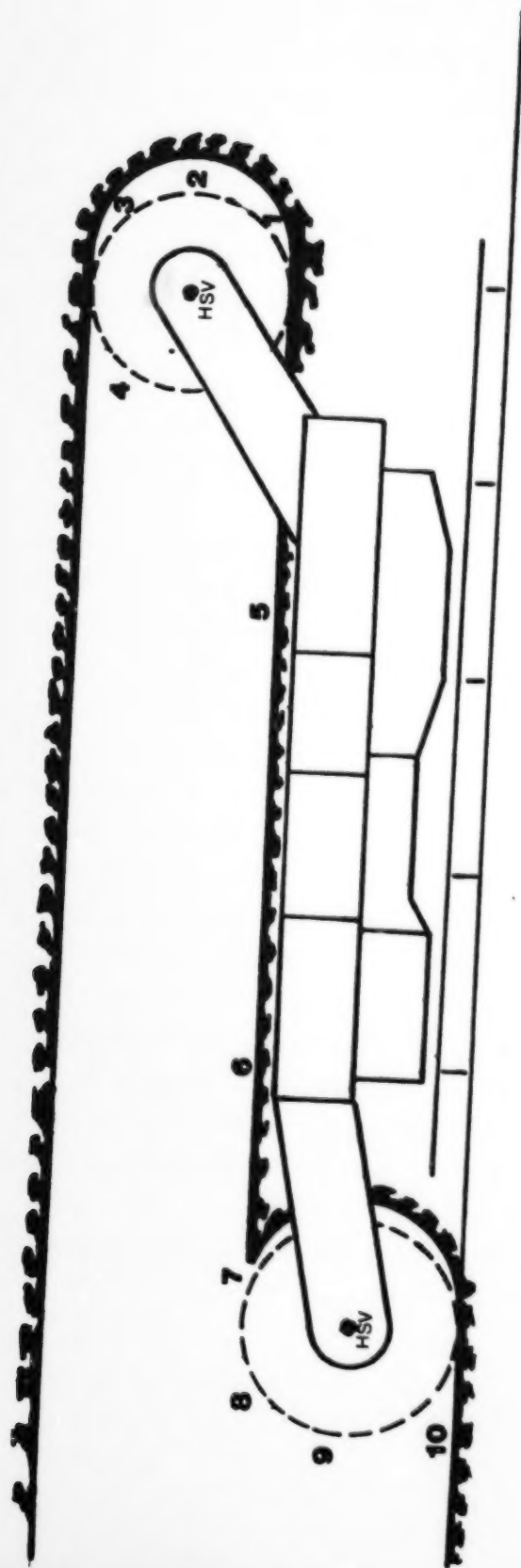


Figure 1 - Numbers 1 - 10 show areas of sampling used in Tables 1 - 5

TEST RESULTS

Before the methane-air mixture samples were withdrawn from the cutting zone, airflow induced by the venturi nozzles were measured for each hollow shaft ventilator. Knowing both the volume of the airflow and the rate of the tracer gas discharge within the hollow shaft, the expected concentration of tracer gas delivered into the confined area of the cutting zone could be calculated. Using the results of the methane-air sample analysis it was possible to deduce the percentage ratio between the volume of air received in the cutting zone via the hollow shaft and the volume of air derived from the general air and entrained by the revolving vanes. The results obtained are listed in the following Tables 1 - 5. The two last columns in each table present the measured CH_4 concentrations in the collected samples and the expected methane concentrations in the sampled zones without the influence of the H.S.V.

CONCLUSIONS

Although the hollow shaft ventilator tests have been performed in limited numbers over a relatively short period of time, they can, nevertheless, serve as a basis for more informed opinions about the performance of H.S.V. installed on shearers at Langan Mine.

The conclusion concerning their efficiencies is obvious; hollow shaft ventilators did not decrease the methane levels in the confined zones of cutting by any significant degree and their levels of performance were far below those claimed by the manufacturers.

The comparison of the data contained in the two last columns presented in Tables 1 - 5 illustrate decreases in methane concentrations in a range of 0 - 12% in the cutting zones of the shearer drum picks.

It is inferred from the results of these trials that the performance levels of the hollow shaft ventilators tested are generally

inadequate. It is considered that better performance can be obtained by addressing the following matters:

- a) The selection of a nozzle or nozzles of suitable diameters and profiles to the bores of any given hollow shaft ventilators.
- b) The provision of suitable higher pressure levels to secure the effective and efficient operation of the selected nozzles.
- c) The precise positioning of the nozzle within the length of the bore of a hollow shaft ventilator.
- d) The incorporation of hollow shaft ventilators as items under a scheme of planned preventive maintenance.
- e) The attention of the shearer operators to the frequent cleaning of small coal from the bore of the hollow shaft ventilators during each working shift.

REFERENCES

1. Klinowski, W.G. and Stokes, A.W. 'Field measurements of airflows induced through hollow shaft venturis on double ended ranging drum shearers in the Sydney Coalfield'; CANMET Division Report ERP/CRL 85-6(CF); 1985.

Table 1 - May 15, 1986 - 6 West, support #50 - shearer cutting "with" the airflow

Sample Location (See Fig. 1)	H.S.V. Airflow 1/min (cfm)	SF ₆ Flow Rate ml/min	H.S.V. SF ₆ Concentration (ppb)	SF ₆ Concentration in sample (ppb)	% of Volume due to H.S.V. (%)	CH ₄ Concentration (%)	Expected CH ₄ Concentration without H.S.V. (%)
1	2549 (90)	46	18000	240	1.3	0.33	0.33 (no change)
1	2549 (90)	46	18000	180	1.0	0.34	0.34 (no change)
2	2549 (90)	46	18000	90	0.5	0.05	0.05 (no change)
3	2549 (90)	46	18000	920	5.1	0.47	0.49
4	2549 (90)	46	18000	1940	10.7	0.52	0.56
5	2549 (90)	46	18000	0.9	no influence	0.41	0.41 (no change)
6	2549 (90)	46	18000	0.	no influence	0.44	0.44 (no change)
7	0	N/A	N/A	N/A	N/A	0.47	N/A
8	0	N/A	N/A	N/A	N/A	0.26	N/A
9	0	N/A	N/A	N/A	N/A	0.29	N/A
10	0	N/A	N/A	N/A	N/A	0.35	N/A

NOTES: 1) Trailing (RH) drum hollow shaft ventilator not working during the survey.

2) General air body CH₄ concentration before shearers pass = 0.2%.

Table 2 - May 28, 1986 - 6 West, support #115 - shearer cutting "against" the airflow

Sample Location (See Fig. 1)	H.S.V. Airflow 1/min (cfm)	SF ₆ Flow Rate ml/min	H.S.V. SF ₆ Concentration (ppb)	SF ₆ Concentration in sample (ppb)	% of Volume due to H.S.V. (%)	CH ₄ Concentration (%)	Expected CH ₄ Concentration without H.S.V. (%)
1	850 (30)	46	54120	500	0.9	0.42	0.42 (no change)
2	850 (30)	46	54120	490	0.9	0.34	0.34 (no change)
3	SAMPLE BAG PUNCTURED			N/A	N/A	N/A	N/A
4	850 (30)	46	54120	1000	1.85	2.03	2.06
5	SAMPLE BAG PUNCTURED			N/A	N/A	N/A	N/A
6	850 (30)	46	54120	0.2	≈ 0	0.61	0.61 (no change)
7	2266 (80)	46	20300	11.3	0.05	0.46	0.46 (no change)
8	2266 (80)	46	20300	0.9	≈ 0	0.41	0.41 (no change)
9	2266 (80)	46	20300	24	0.12	0.83	0.83 (no change)
10	2266 (80)	46	20300	21	0.1	0.54	0.54 (no change)

NOTES: 1) Two bags punctured during transportation - samples lost.

2) General air body methane concentration

- before shearers pass - 0.30% (used for calculating the expected CH₄ concentration without H.S.V.)

- after shearers pass - 0.455%.

Table 3 - June 18, 1986 - 6 West, support #18 - shearer cutting "with" the airflow

Sample Location	H.S.V. Airflow (See Fig. 1) 1/min (cfm)	SF ₆ Flow Rate ml/min	H.S.V. SF ₆ Concentration (ppb)	SF ₆ Concentration in sample (ppb)	% of Volume due to H.S.V. (%)	CH ₄ Concentration (%)	Expected CH ₄ Concentration without H.S.V. (%)
1	3120 (110)	44	14100	591	4.2	0.19	0.19 (no change)
2	3120 (110)	44	14100	205	1.5	0.15	0.15 (no change)
3	3120 (110)	44	14100	79	0.56	0.18	0.18 (no change)
4	3120 (110)	44	14100	8	0.05	0.14	0.14 (no change)
4	3120 (110)	44	14100	16	0.1	0.11	0.11 (no change)
5	3120 (110)	44	14100	16	0.1	0.17	0.17 (no change)
5	3120 (110)	44	14100	8	0.05	0.16	0.16 (no change)
6	3120 (110)	44	14100	8	0.06	0.20	0.20 (no change)
6	3120 (110)	44	14100	8	0.06	0.12	0.12 (no change)
6	3120 (110)	44	14100	8	0.06	0.10	0.10 (no change)
7	1420 (50)	44	30985	1475	4.76	0.16	0.16 (no change)
8	1420 (50)	44	30985	181	0.58	0.14	0.14 (no change)
9	1420 (50)	44	30985	8	0.03	0.10	0.10 (no change)
10	1420 (50)	44	30985	8	0.03	0.16	0.16 (no change)

NOTES: 1) General air body methane concentration

- before shearers pass - 0.16% (used for calculating the expected CH₄ concentration without H.S.V.)

- after shearers pass - 0.21%.

Table 4 - July 16, 1986 - 10 East, support #130 - shearer cutting "with" the airflow

Sample Location (See Fig. 1)	H.S.V. Airflow 1/min (cfm)	SF ₆ Flow Rate ml/min	H.S.V. SF ₆ Concentration (ppb)	SF ₆ Concentration in sample (ppb)	% of Volume due to H.S.V. (%)	CH ₄ Concentration (%)	Expected CH ₄ Concentration without H.S.V. (%)
1	2690 (95)	44	16360	2243	13.71	1.12	1.19
2	2690 (95)	44	16360	1625	9.94	1.40	1.48
3	2690 (95)	44	16360	946	5.78	0.93	0.94
4	2690 (95)	44	16360	1576	9.63	0.95	1.01
5	2690 (95)	44	16360	267	1.63	1.16	1.17
6	2690 (95)	44	16360	303	1.85	0.85	0.85 (no change)
7	2690 (95)	44	16360	679	4.15	0.87	0.88
8	2690 (95)	44	16360	1006	6.15	1.02	1.04
9	2690 (95)	44	16360	1030	6.30	1.11	1.14
10	2690 (95)	44	16360	1285	7.85	0.97	0.99

NOTES: 1) General air body methane concentration

- before shearers pass - 0.70% (used for calculating the expected CH₄ concentration without H.S.V.)
- after shearers pass - 0.93%.

Table 5 - July 16, 1986 - 10 East, support #121 - shearer cutting "against" the airflow

Sample Location (See Fig. 1)	H.S.V. Airflow 1/min (cfm)	SF ₆ Flow Rate ml/min	H.S.V. SF ₆ Concentration (ppb)	SF ₆ Concentration in sample (ppb)	% of Volume due to H.S.V. (%)	CH ₄ Concentration (%)	Expected CH ₄ Concentration without H.S.V. (%)
1	2690 (95)	44	16360	2218	13.56	1.24	1.37
2	2690 (95)	44	16360	812	4.96	0.68	0.69
3	2690 (95)	44	16360	352	2.15	0.58	0.58 (no change)
4	2690 (95)	44	16360	400	2.45	0.65	0.65 (no change)
5	2690 (95)	44	16360	836	5.11	0.89	0.92
6	2690 (95)	44	16360	170	1.04	0.76	0.77
7	2690 (95)	44	16360	36	0.22	LOST SAMPLE	N/A
8	2690 (95)	44	16360	121	0.74	1.04	1.04 (no change)
9	2690 (95)	44	16360	388	2.37	1.06	1.08
10	2690 (95)	44	16360	2376	14.53	1.35	1.51

NOTES: 1) General air body methane concentration

- before shearers pass - 0.40% (used for calculating the expected CH₄ concentration without H.S.V.)

- after shearers pass - 0.72%.